SOLUBILITY REVIEW QUESTIONS

Solubility Problem Set 1

1. What is the solubility of calcium sulphate in M, g/L, and g/100 mL?

2. What is the solubility of silver chromate? In a saturated solution of silver chromate, what is the concentration of each ion?

3. What is the solubility of silver chromate in a solution that is 0.24 M in silver nitrate?

4. What is the maximum concentration of chromate ion that is allowed before silver chromate will precipitate if the silver ion concentration is 7.8×10^{-4} M?

5. How many lead(II) and iodate ions are present in 3.8 L of a saturated solution of lead(II) iodate?

6. Will a precipitate form if 34 mL of 8.8×10^{-3} M lead(II) nitrate are mixed with 79 mL of 3.2×10^{-3} M sodium iodate?

7. How many precipitates will form if 25 mL of 7.5×10^{-2} M magnesium sulphate is mixed with 0.044 L of 3.8×10^{-2} M strontium hydroxide?

8. How many grams of magnesium carbonate are dissolved in 2.3 L of a saturated solution?

9. Devise a method to separate the following ions from a mixture and provide a net ionic equation for each step:
   a) Ag^+, Sr^{2+}, and Cu^{2+} b) SO_3^{2-}, SO_4^{2-}, and Br^-

10. Describe the changes to rate(dissolving), rate(crystallizing), solubility ("s"), and K_{sp} when additional compound is added to an already saturated solution of the compound.

Answers to Solubility Problem Set 2 (for questions on the other side):

1. 3.7×10^{-19} 2. $[Ca^{2+}] = [SO_4^{2-}] = 8.4 \times 10^{-3}$ M
3. $[Ca^{2+}] = 2.3 \times 10^{-4}$ M, $[F^-] = 4.6 \times 10^{-4}$
4. 8.5×10^{-15} g/L
5. $K_{TIP} = 5.8 \times 10^{-7}$ $\therefore$ ppt forms
6. $K_{TIP} = 9.4 \times 10^{-7}$ $\therefore$ ppt forms
7. a) 2.5×10^{-5} b) 3.7×10^{-9}
8. K_{sp} (at temperature X °C) = 1.1×10^{-8}, $\therefore$ X °C > 25 °C
9. 1.3×10^{-3} M (pure water), 1.5×10^{-4} M (0.10 M $Pb(NO_3)_2$)
10. a) Sr^{2+} b) $[Sr^{2+}] = 6.6 \times 10^{-3}$ M
11. 5.0×10^{1} mL 12. 0.0162 M

SOLUBILITY REVIEW QUESTIONS

Solubility Problem Set 2

1. In a saturated solution of FeS, the $[Fe^{2+}]$ and the $[S^{2-}]$ are both 6.08×10^{-10} M. Calculate the value of K_{sp}.

2. Find $[Ca^{2+}]$ and $[SO_4^{2-}]$ in a saturated solution of $CaSO_4$.

3. Find $[Ca^{2+}]$ and $[F^-]$ in a saturated solution of CaF_2. K_{sp} for CaF_2 is 4.9×10^{-11}.

4. Find the solubility of Ag_2S in water in g/L. K_{sp} for Ag_2S is 1.6×10^{-49}.

5. Will a precipitate form if 10.0 mL of 0.010 M $AgNO_3$ is mixed with 25.0 mL of 0.10 M Na_2CO_3?

6. Will a precipitate form if 5.0 mL of 0.0040 M $AgNO_3$ is added to 15.0 mL of a solution containing 1.5 mg of bromide ions? (How does the mass of Br compare to Br^-?)

7. Calculate the K_{sp} for each of the salts whose solubility is:
   a) $CaSO_4$: 5.0×10^{-3} M b) SrF_2: 12.2 mg/100 mL.

8. Can the temperature of 2.5 L of a saturated AgCl solution containing 38 mg of dissociated AgCl be 25 °C? If the dissociation of the solid phase to the aqueous phase is endothermic, how does the temperature of this saturated solution compare to one at 25 °C?

9. Compare the molar solubility of PbI_2 in pure water and in 0.10 M $Pb(NO_3)_2$.

10. A 1.0 L solution contains 0.010 M Ag^+ ions and 0.010 M Sr^{2+} ions.
    a) Which ion precipitates first when K_2CO_3 is added to the mixture? Assume no change in volume.
    b) What is the concentration of the ion that is precipitated first when the second ion begins to precipitate?

11. Barium nitrate reacts with potassium sulphate solution and forms insoluble barium sulphate. What volume of 0.40 M $Ba(NO_3)_2$ solution is required to precipitate the sulphate ions in 25.00 mL of 0.80 M K_2SO_4?

12. A 225 mL sample of tap water containing the chloride ion requires 36.42 mL of 0.100 M $AgNO_3$ to titrate. What is the chloride concentration in the tap water?

Answers to Solubility Problem Set 1 (for questions on the other side):

1. 8.4×10^{-3} M, 1.1 g/L, 0.11 g/100 mL
2. s = 6.5×10^{-5}, $[Ag^+] = 1.3 \times 10^{-4}$ M, $[CrO4^{2-}] = 6.5 \times 10^{-5}$ M
3. 1.9×10^{-11} M 4. 1.8×10^{-6} M 5. 1.0×10^{20} Pb^{2+} ions, 2.0×10^{20} IO_3^- ions
6. $K_{TIP} = 1.3 \times 10^{-8} > K_{sp}$, therefore a ppt will form
7. K_{TIP} $(Mg(OH)_2) = 6.4 \times 10^{-5}$, K_{TIP} $(SrSO_4) = 6.6 \times 10^{-4}$, ∴ two ppt's form
8. 0.51 g
9. a) 1. add NaCl: $Ag^+_{(aq)} + Cl^-_{(aq)} \text{-----> } AgCl_{(s)}$ (filter)
      2. add Na_2SO_4: $Sr^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \text{-----> } SrSO_{4(s)}$ (filter)
      3. add Na_3PO_4: $3\ Cu^{2+}_{(aq)} + 2\ PO_4^{3-}_{(aq)} \text{-----> } Cu_3(PO_4)_{2(s)}$ (filter)
   b) 1. add $Mg(NO_3)_2$: $Mg^{2+}_{(aq)} + SO_3^{2-}_{(aq)} \text{-----> } MgSO_{3(s)}$ (filter)
      2. add $Ba(NO_3)_2$: $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \text{-----> } BaSO_{4(s)}$ (filter)
      3. add $Pb(NO_3)_2$: $Pb^{2+}_{(aq)} + 2\ Br^-_{(aq)} \text{-----> } PbBr_{2(s)}$ (filter)
10. rate(dissolution) = increase, rate(crystallization) = increase, s = no change, K_{sp} = no change

SOLUBILITY REVIEW QUESTIONS

1. The equation for silver chromate dissolving in water is

$$Ag_2CrO_{4(s)} \leftrightarrow 2\ Ag^+_{(aq)} + CrO_4^{2-}{}_{(aq)}$$

What is the K_{sp} expression?
a) $[Ag^+]^2[CrO_4^{2-}]$
b) $[Ag^+][CrO_4^{2-}]^2$
c) $[2\ Ag^+][CrO_4^{2-}]$
d) $[Ag^+]^2[CrO_4^{2}] / [Ag_2CrO_4]$

2. What is the solubility of silver chloride, AgCl, in water, given K_{sp} (AgCl) = 1.8×10^{-10} ?
a) 3.24×10^{-20} M
b) 1.80×10^{-10} M
c) 1.34×10^{-5} M
d) 1.9×10^{-3} M

3. What is the solubility of lead II iodide (PbI_2) in water, given K_{sp} (PbI_2) = 7.10×10^{-9} ?
a) 7.10×10^{-9} M
b) 8.44×10^{-5} M
c) 1.92×10^{-3} M
d) 1.21×10^{-3} M

4. 10.0 mL of 1.00×10^{-5} M $AgNO_3$ and 30.0 mL of 2.00×10^{-4} M NaCl are mixed. K_{sp} (AgCl) = 1.8×10^{-10}. Which one of the following occurs?
a) Ion product is 3.75×10^{-10} and precipitate forms.
b) Ion product is 3.75×10^{-10} and precipitate does not form.
c) Ion product is 2.00×10^{-9} and precipitate forms.
d) Ion product is 2.00×10^{-9} and precipitate does not form.

5. What is the highest concentration of magnesium ion possible at equilibrium in a solution containing 2.0×10^{-2} M oxalate ions ($C_2O_4^{2-}$) given that K_{sp} (MgC_2O_4) = 8.6×10^{-5} ?
a) 4.3×10^{-3} M
b) 5.16×10^{-2} M
c) 1.04×10^{-1} M
d) 2.33×10^{-2} M

6. What is the equilibrium concentration of $Sr^{2+}_{(aq)}$ in a saturated aqueous solution of $SrSO_4$? (K_{sp} of $SrSO_4$ = 2.8×10^{-7})
a) 1.4×10^{-7} M
b) 2.8×10^{-7} M
c) 5.3×10^{-4} M
d) 5.3×10^{-3} M

SOLUBILITY REVIEW QUESTIONS

7. $PbCl_{2\,(s)}$ is precipitated from a solution containing $Pb^{2+}_{(aq)}$ and $Cl^{-}_{(aq)}$. Which one of the following relationships describes the concentrations of the ions remaining in the solution?
   a) $[Pb^{2+}]^2[Cl^-] = K_{sp}$ of $PbCl_{2\,(s)}$
   b) $[Pb^{2+}]^2[Cl^-]^2 = K_{sp}$ of $PbCl_{2\,(s)}$
   c) $[Pb^{2+}][Cl^-] = K_{sp}$ of $PbCl_{2\,(s)}$
   d) $[Pb^{2+}][Cl^-]^2 = K_{sp}$ of $PbCl_{2\,(s)}$

8. Which one of the following statements is TRUE about the result of mixing equal volumes of 0.020 M $CaCl_2$ and 0.00040 M Na_2SO_4?
   (K_{sp} for $CaSO_{4\,(s)} = 2.4 \times 10^{-5}$)
   a) The trial product is smaller than the K_{sp} and a precipitate will form.
   b) The trial product is larger than the K_{sp} and a precipitate will form.
   c) The trial product is smaller than the K_{sp} and a precipitate will not form.
   d) The trial product is larger than the K_{sp} and a precipitate will not form.

9. The K_{sp} for the salt MA_2 is 4.0×10^{-6}. What is the $[M^{2+}]$ in a saturated solution formed by dissolving $MA_{2\,(s)}$ in water?
   a) 1.0×10^{-3} M
   b) 2.0×10^{-3} M
   c) 1.0×10^{-2} M
   d) 1.6×10^{-2} M

10. Silver acetate, $AgCH_3COO_{(s)}$, crystals are in equilibrium with a saturated solution. Which of the following would cause more $AgCH_3COO_{(s)}$ to dissolve?
    a) The addition of a few crystals of silver nitrate.
    b) The addition of a few drops of concentrated nitric acid.
    c) The addition of a few crystals of sodium acetate.
    d) The evaporation of some water from the solution with no temperature change.

11. 1.0 L of a saturated solution of thallium bromide (TlBr) was evaporated to dryness to produce 0.56 g of $TlBr_{(s)}$. What is the K_{sp} of thallium bromide? (molar mass of TlBr = 284 g / mol)
    a) 2.0×10^{-6}
    b) 3.9×10^{-6}
    c) 2.0×10^{-3}
    d) 4.4×10^{-2}

12. A solution contains $Ba^{2+}_{(aq)}$, $Pb^{2+}_{(aq)}$, $Fe^{2+}_{(aq)}$, and $Mg^{2+}_{(aq)}$. Which of the following negative ions would cause a precipitate with only one of those metals?
    a) $I^-_{(aq)}$
    b) SO_4^{2-}
    c) $NO_3^-{}_{(aq)}$
    d) $PO_4^{3-}{}_{(aq)}$

13. The K_{sp} for PbS is 3.4×10^{-28}. What is the $[S^{2-}]$ in a saturated solution of PbS?
    a) 4.4×10^{-10} M
    b) 5.9×10^{-13} M
    c) 1.8×10^{-14} M
    d) 1.7×10^{-28} M

14. Phosphate ions, PO_4^{3-}, form a compound of low solubility with
    a) NH_4^+
    b) K^+
    c) H^+
    d) Ca^{2+}

15. Some solid $NaCH_3COO$ is added to a saturated $AgCH_3COO$ solution in contact with $AgCH_3COO$ crystals. Which of the following occurs?
    a) The $NaCH_3COO$ solid does not dissolve.
    b) More $AgCH_3COO$ dissolves.
    c) $AgCH_3COO$ precipitates.
    d) There is no change in the amount of dissolved $AgCH_3COO$.

16. The process by which ions are surrounded by water molecules is called
    a) hydration.
    b) ionization.
    c) hydrolysis.
    d) dissociation.

17. Which is the most soluble of the silver salts listed below?
    a) AgBr $K_{sp} = 5.0 \times 10^{-13}$
    b) $AgBrO_3$ $K_{sp} = 4.0 \times 10^{-5}$
    c) AgCl $K_{sp} = 1.7 \times 10^{-10}$
    d) $AgIO_3$ $K_{sp} = 4.0 \times 10^{-8}$

18. When crystals of ammonium chloride are added to water, the crystals dissolve readily and the temperature decreases. The dissolving of ammonium chloride in water is therefore
    a) endothermic and spontaneous.
    b) exothermic and spontaneous.
    c) endothermic but not spontaneous.
    d) exothermic but not spontaneous.

19. Which of the following anions in a concentrated solution will form a precipitate with 0.10 M Pb^{2+} but will not form a precipitate with 0.10 M Ba^{2+}?
    a) CO_3^{2-}
    b) SO_4^{2-}
    c) PO_4^{3-}
    d) Cl^-

20. K_{sp} for $PbCO_3$ is 3.2×10^{-14}. What is the solubility of $PbCO_3$ in moles per litre?
    a) 1.6×10^{-14}
    b) 1.8×10^{-7}
    c) 2.0×10^{-5}
    d) 1.0×10^{-27}

21. A solution of $SrCl_2$ is added to a solution of $CuSO_4$ and a precipitate forms. According to the solubility table, the precipitate is probably
    a) $SrSO_4$
    b) CuCl
    c) $CuCl_2$
    d) Both $SrSO_4$ and CuCl.

22. 20.0 mL of 0.012 M $AgNO_3$ is added to 20.0 mL of 0.018 M $NaBrO_3$. The K_{sp} for $AgBrO_3$ is 5.8×10^{-5}. Which of the following statements is correct?
    a) The trial ion product is 2.2×10^{-4} and a precipitate will form.
    b) The trial ion product is 2.2×10^{-4} and a precipitate will not form.
    c) The trial ion product is 5.4×10^{-5} and a precipitate will form.
    d) The trial ion product is 5.4×10^{-5} and a precipitate will not form.

23. According to the table of solubilities, what will happen when 0.1 M solutions of $Ba(OH)_2$ and $Fe_2(SO_4)_3$ are mixed.
    a) No precipitates will form.
    b) Only $BaSO_4$ will precipitate.
    c) Only $Fe(OH)_3$ will precipitate.
    d) Both $BaSO_4$ and $Fe(OH)_3$ will precipitate.

24. The equation for the dissolving of Ag_2SO_4 in water is

$$Ag_2SO_{4(s)} \leftrightarrow 2\ Ag^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

    If $Ag_2SO_{4(s)}$ is in equilibrium with a saturated solution, which of the following will result in more $Ag_2SO_{4(s)}$ dissolving?
    a) Add H_2SO_4 solution.
    b) Add $AgNO_3$.
    c) Add more $Ag_2SO_{4(s)}$.
    d) Add Cl^- which precipitates AgCl.

25. The solubility of copper I bromide, CuBr is 2.0×10^{-4} mol / L. What is the value of K_{sp} for CuBr?
    a) 3.2×10^{-11} M
    b) 4.0×10^{-8} M
    c) 1.4×10^{-2} M
    d) 2.9×10^{-2} M

26. What is the maximum $[Mg^{2+}]$ that can exist in a solution of 1.0×10^{-3} M NaOH without precipitating $Mg(OH)_2$? (K_{sp} for $Mg(OH)_2$ is 1.2×10^{-11})
a) 1.2×10^{-8} M
b) 1.2×10^{-5} M
c) 1.4×10^{-4} M
d) 5.0×10^{-4} M

27. Which one of the following statements is TRUE about what occurs when 30.0 mL of 8.00×10^{-8} M $CaNO_3$ is mixed with 10.0 mL of 3.0×10^{-2} M NaF? (K_{sp} for $CaF_2 = 4.9 \times 10^{-11}$)
a) The trial ion product is 4.5×10^{-10} and a precipitate forms.
b) The trial ion product is 2.4×10^{-10} and a precipitate forms.
c) The trial ion product is 3.4×10^{-12} and a precipitate does not form.
d) The trial ion product is 4.5×10^{-10} and a precipitate does not form.

28. Which one of the following conditions will result in the formation of a precipitate of AgCl when solid NaCl is added to a solution of silver nitrate ($AgNO_3$)?
a) The product of the molar concentrations of aqueous Ag^+ and Cl^- ions is less than the K_{sp} for AgCl.
b) No precipitate will occur unless the solution becomes saturated with NaCl first.
c) The product of the molar concentrations of aqueous Ag^+ and Cl^- ions exceeds the K_{sp} of AgCl.
d) The concentration of aqueous Na^+ ions is greater than the concentration of the aqueous Ag^+ ions.

29. The solubility of $Cd(OH)_2$ in water is the 1.40×10^{-5} M. What is the value of the solubility product constant K_{sp}?
a) 2.74×10^{-15}
b) 1.10×10^{-14}
c) 1.71×10^{-10}
d) 1.43×10^{-5}

30. Which one of the following occurs when equal volumes of 0.20 $Ba(NO_3)_2$ and 0.20 M K_2SO_4 are mixed?
a) No precipitate forms.
b) A precipitate of KNO_3 forms.
c) A precipitate of $BaSO_4$ forms.
d) Insufficient information is available to answer the question.

31. Which of these ions could be used to distinguish between Na^+ ions and Mg^{2+} ions in solution?
a) H^+
b) Cl^-
c) SO_4^{2-}
d) OH^-

32. What is the K_{sp} for $CaCO_3$ if 0.0014 grams can dissolve in water to make 100.0 mL of solution?
a) 1.4×10^{-4}
b) 1.4×10^{-5}
c) 2.0×10^{-8}
d) 2.0×10^{-10}

33. What is the relationship between the rate of dissolving and the rate of precipitation in a saturated solution where excess solute is present?
a) The rate of dissolving equals the rate of precipitation.
b) The rate of dissolving is less than the rate of precipitation.
c) The rate of dissolving is greater than the rate of precipitation.
d) The rate of dissolving and the rate of precipitation are zero.

34. What is the $[Ni^{2+}]$ in a saturated solution of $Ni(OH)_2$?
a) Less than 0.10 M
b) Greater than 0.10 M but less than 1.0 M
c) Greater than 1.0 M but less than 5.0 M
d) Greater than 5.0 M

35. Which of the following salts has the greatest solubility in water?
a) AgCl
b) $BaSO_4$
c) $MgCO_3$
d) $NaCH_3COO$

36. For the following solubility equilibrium, what is the K_{sp} expression?

$$Ag_2S_{(s)} \leftrightarrow 2\ Ag^+_{(aq)} + S^{2-}_{(aq)}$$

a) $K_{sp} = [Ag^+][S^{2-}]$
b) $K_{sp} = [2Ag^+][S^{2-}]$
c) $K_{sp} = [Ag^+]^2[S^{2-}]$
d) $K_{sp} = [Ag^+][S^{2-}]^2$

37. A student prepares a saturated solution of lead sulphate by adding an excess of the $PbSO_{4(s)}$ to 1.0 L of water. He finds that 3.4×10^{-2} g of $PbSO_4$ has dissolved. Based on this data, the K_{sp} of $PbSO_4$ is
a) 1.1×10^{-4}
b) 1.2×10^{-3}
c) 1.3×10^{-8}
d) 3.4×10^{-2}

38. What is the maximum number of moles of $I^-_{(aq)}$ that may exist in a 1.0 L solution which has a $[Pb^{2+}]$ of 2.0×10^{-4} M ? (K_{sp} of $PbI_2 = 1.4 \times 10^{-8}$)
a) 1.4×10^{-2} mol
b) 3.5×10^{-5} mol
c) 7.0×10^{-5} mol
d) 8.4×10^{-3} mol

39. In which of the following solutions is $Pb(CH_3COO)_2$ MOST soluble?
a) 0.1 M HNO_3
b) 0.1 M $NaNO_3$
c) 0.1 M $NaCH_3COO$
d) 0.1 M $Ca(CH_3COO)_2$

40. $BaSO_4$ has a low solubility in water. The equation for the dissolving of $BaSO_4$ is

$$BaSO_{4\,(s)} + \text{energy} \leftrightarrow Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

Which of the following changes would increase the solubility of $BaSO_{4\,(s)}$?
a) Add Na_2SO_4.
b) Add $Ba(NO_3)_2$.
c) Add more water.
d) Increase the temperature.

41. A solution that will not dissolve additional solute is
a) insoluble.
b) saturated.
c) unsaturated.
d) unsolvated.

42. When gold (III) chloride, $AuCl_3$, is dissolved in water, analysis would show that
a) $[Cl^-] = [Au^{3+}]$
b) $[Cl^-] = 3 \times [Au^{3+}]$
c) $[Cl^-] = [Au^{3+}]^3$
d) $[Cl^-] = ⅓ \times [Au^{3+}]$

43. When equal volumes of 0.20 M solutions of the following solutes are mixed, which combination will produce a precipitate?
a) K_2S and NaOH
b) $BaBr_2$ and NaOH
c) $MgCl_2$ and NaOH
d) $(NH_4)_2SO_4$ and NaOH

44. What is the net ionic equation for the precipitation reaction when aqueous solutions of Na_2CO_3 and $AgNO_3$ are mixed?
a) $2\ AgNO_{3\,(aq)} + Na_2CO_{3\,(aq)} \rightarrow Ag_2CO_{3\,(s)} + 2\ NaNO_{3\,(aq)}$
b) $Ag_2CO_{3\,(s)} \rightarrow 2\ Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)}$
c) $Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow Ag_2CO_{3\,(s)}$
d) $2\ Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow Ag_2CO_3\,(s)$

45. Which of the following salts is LEAST soluble in water?
a) CuS $\quad K_{sp} = 8.5 \times 10^{-45}$
b) $CuCO_3$ $\quad K_{sp} = 7.4 \times 10^{-21}$
c) CuBr $\quad K_{sp} = 5.3 \times 10^{-9}$
d) CuCl $\quad K_{sp} = 1.2 \times 10^{-6}$

46. If K_{sp} of $PbSO_4$ is 1.7×10^{-8}, what is the solubility of $PbSO_4$?
    a) 2.9×10^{-16}
    b) 1.3×10^{-8}
    c) 1.7×10^{-8}
    d) 1.3×10^{-4}

47. Which of the following will form an ionic solution when 0.1 mol dissolve in 1.0 L of water?
    a) Br_2
    b) NaCl
    c) CH_3OH
    d) $C_6H_{11}OH$

48. When 0.2 M Rb_3PO_4 is mixed with an equal volume of 0.2 M CaS, the precipitate will be
    a) CaS
    b) Rb_2S
    c) Rb_3PO_4
    d) $Ca_3(PO_4)_2$

49. Which anion below could be used to separate Sr^{2+} from Pb^{2+} by precipitation?
    a) Cl^-
    b) SO_4^{2-}
    c) CO_3^{2-}
    d) PO_4^{3-}

50. What is the maximum $[Zn^{2+}]$ possible in a solution containing 0.010 M OH^- ? (K_{sp} $Zn(OH)_2$ is 1.8×10^{-14})
    a) 1.8×10^{-18} M
    b) 1.8×10^{-16} M
    c) 1.8×10^{-12} M
    d) 1.8×10^{-10} M

51. Consider the following equilibrium equation for a saturated solution of Ag_2CO_3:

$$Ag_2CO_{3\,(s)} \leftrightarrow 2\,Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

    Which of the following, when added to this saturated solution, would acuse more Ag_2CO_3 solid to dissolve?
    a) HNO_3
    b) $AgNO_3$
    c) Ag_2CO_3
    d) Na_2CO_3

52.

Temperature	Solubility of $Ca(CH_3COO)_2$
0°C	37.4 g / 100 g H_2O
100°C	29.7 g / 100 g H_2O

Use the information above to answer the following:

A saturated solution of $Ca(CH_3COO)_2$ at 20°C is warmed to 30°C. The solubility of $Ca(CH_3COO)_2$ will
a) more than double.
b) increase slightly.
c) remain the same.
d) decrease slightly.

53. The solubility of KI is 35 g of KI per 100 g of H_2O at 20°C. A KI solution at 20°C containing 25 g of KI per 100 g H_2O would be
a) saturated.
b) insoluble
c) unsaturated
d) supersaturated

54. The NO_3^- ion concentration in a 0.10 M solution of $Ba(NO_3)_2$ is
a) 0.10 M
b) 0.13 M
c) 0.20 M
d) 0.50 M

55. Which compound has the lowest solubility at 25°C ?
a) CuI
b) CaS
c) $FeSO_4$
d) $Pb(CH_3COO)_2$

56. Which ion should be used to remove the cations Ca^{2+} and Mg^{2+} from 'hard' water?
a) CO_3^{2-}
b) Cl^-
c) NO_3^-
d) CH_3COO^-

57. The K_{sp} expression for a saturated $Fe(OH)_3$ solution is:
a) $K_{sp} = [Fe^{3+}][3OH^-]^3$
b) $K_{sp} = [Fe^{3+}][OH^-]^3$
c) $K_{sp} = [Fe^{3+}][3OH^-] / [Fe(OH)_3]$
d) $K_{sp} = [Fe^{3+}][OH^-]^3 / [Fe(OH)_3]$

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For the remainder of the questions, marks will be awarded as shown. Your steps and assumptions leading to a solution must be shown. In questions involving calculations, full marks will not be given for providing only an answer. Students will be expected to communicate the knowledge and understanding of chemical principles in a clear and logical manner.

1. For the reaction

   $Ag_2CO_{3\,(s)} \leftrightarrow 2\ Ag^+_{(aq)} + CO_3^{2-}$

   what will be the effect on the position of this equilibrium of adding solid $AgNO_3$?Give a brief explanation for your answer. (2 marks)

2. The solubility of thallium iodate, $TlIO_3$, is 1.5×10^{-3} M at 25°C.
   What is the K_{sp} at this temperature? (2 marks)

3. Explain why a precipitate of AgCl will NOT be produced when 20.0 mL of 3.00×10^{-6} M $AgNO_3$ is mixed with 30.0 mL of 1.00×10^{-4} M NaCl. For AgCl, the $K_{sp} = 1.8 \times 10^{-10}$. Support your explanation by calculation. (4 marks)

4. The equilibrium in a saturated ZnF_2 solution is given by:

   $ZnF_{2\,(s)} \Leftrightarrow Zn^{2+}_{(aq)} + 2\ F^-_{(aq)}$

   Predict the effect on the solubility of ZnF_2 of adding some solid KF. Explain the reasoning for your prediction. (2 marks)

5. What is the minimum mass of $Na_2SO_{4\,(s)}$ crystals that must be dissolved in 5.0 L of 0.0010 M $Ca(NO_3)_2$ solution in order to initiate precipitation of calcium sulphate? (4 marks) K_{sp} for $CaSO_4 = 2.6 \times 10^{-5}$

6. Calculate the value of the K_{sp} for SrF_2 if the solubility is 0.122 g/L. (4 marks)

7. The K_{sp} for $PbSO_4$ is 1.3×10^{-8} at 25°C. Calculate the mass in grams of $PbSO_4$ which could be dissolved in 5.0 L of water at 25°C. (3 marks)

8. 30.0 mL of 0.10 M LiCl is added to 20.0 mL of 0.20 M Na_2CO_3. The K_{sp} for Li_2CO_3 is 1.7×10^{-3}. WIll Li_2CO_3 precipitate? Support your answer with calculations. (3 marks)

9. A beaker contains OH^- and $S^{2=}$ ions in solution, both at a concentration of 0.10 M. You are asked to precipitate the OH^- while leaving the $S^{2=}$ in solution.
   a) Which reagent could you use? (1 mark)
   b) Write a net ionic equation for the precipitation reaction. (1 mark)
10. Show by calculation and state whether or not a precipitate of $BaSO_4$ will form when 0.150g of K_2SO_4 is added to 2.00 L of 1.70×10^{-5} M $BaCl_{2\,(aq)}$ solution. K_{sp} of $BaSO_4 = 1.5 \times 10^{-9}$. (4 marks)

11. What happens to the solubility of $CaSO_4$ when K_2SO_4 is added to a saturated solution of $CaSO_4$? Explain your answer. (2 marks)

12. A solution contains Ag^{+}, Sr^{2+}, and Ba^{2+} all at a concentration of 0.10 M. When KI is added, a yellow precipitate is formed. Identify the precipitate and write the net ionic equation of the reaction. (2 marks)

13. Calculate the mass of $Ba(OH)_2$ dissolved in 5.00 L of a saturated solution of this compound. $K_{sp} = 5.00 \times 10^{-3}$ (4 marks)

CHEMISTRY 12: SOLUBILITY REVIEW QUESTIONS

ANSWERS TO MULTIPLE CHOICE

1	A	16	A	31	D	46	D
2	C	17	B	32	C	47	B
3	D	18	A	33	A	48	D
4	A	19	D	34	A	49	A
5	A	20	B	35	D	50	D
6	C	21	A	36	C	51	A
7	D	22	D	37	C	52	D
8	C	23	D	38	D	53	C
9	C	24	D	39	A	54	C
10	B	25	B	40	D	55	A
11	B	26	B	41	B	56	A
12	A	27	C	42	B	57	B
13	C	28	C	43	C		
14	D	29	B	44	D		
15	C	30	C	45	A		

CHEMISTRY 12: SOLUBILITY REVIEW QUESTIONS
ANSWERS FOR WRITTEN RESPONSE

1. The equilibrium will shift towards the left (more precipitate will be formed). Adding $AgNO_3$ will increase $[Ag^+]$ therefore the system will react by trying to minimize the stress (Le Chatelier's Principle).

2. $K_{sp} = 2.3 \times 10^{-6}$

3. $K_{trial} = 7.2 \times 10^{-11}$. Because K_{trial} is less than K_{sp}, no precipitate will be formed.

4. The equilibrium will shift towards the left (more precipitate will be formed). Adding KF will increase $[F^-]$ therefore the system will react by trying to minimize the stress (Le Chatelier's Principle).

5. 18 grams

6. $K_{sp} = 3.67 \times 10^{-9}$

7. 0.17 grams

8. $K_{trial} = 2.8 \times 10^{-4}$. Because K_{trial} is less than K_{sp}, no precipitate will be formed.

9. a) $Be(NO_3)_2$, $Ca(NO_3)_2$, $Mg(NO_3)_2$
   b) $Mg^{2+}_{(aq)} + 2\ OH^-_{(aq)} \rightarrow Mg(OH)_{2\ (s)}$

10. $K_{trial} = 7.3 \times 10^{-9}$. Because K_{trial} is greater than K_{sp}, a precipitate will be formed.

11. Solubility decreases. Adding K_2SO_4 will cause the $[SO_4^{2-}]$ to increase (because the K_2SO_4 will dissolve). The increase in $[SO_4^{2-}]$ will cause the equilibrium to shift towards producing more $CaSO_{4\ (s)}$.

12. a) AgI
    b) $Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

13. 92.3 grams